

## REMARKS

Applicants appreciate the thoroughness with which the Examiner has examined the above-identified application. Reconsideration is requested in view of the amendments above and the remarks below.

### Rejections under 35 U.S.C. § 112

The Examiner has rejected claims 31-33 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the applicants regard as the invention. Specifically, the term "outputting" in the last limitation of each of the above claims is indefinite.

Applicants have amended claims 31-33 to indicate more precisely that the output is a data file of the corrected phase map. In this regard, the data file represents a transformed array. Specifically, wavefront information is modeled within an array that is operated on by a filtering function.

The method further comprises: forming the first two-dimensional complex array comprising a plurality of complex numbers having amplitude and phase; obtaining a complex conjugate array corresponding to the first two-dimensional complex array; arranging the first two-dimensional complex array into a symmetric complex array using the complex conjugate array; performing an analytic filtering function on the symmetric complex array; applying a power law function to the symmetric complex array; computing the wavefront by performing a Fourier Transform on the symmetric complex array, *resulting in a transformed array*; obtaining a circular core of the transformed array of a diameter equal to the first array's assigned diameter, and converting to zero coordinates outside the diameter; *and normalizing amplitudes of the transformed array*. Specification, ¶ 0024 (emphasis added).

The above-described method computes a phase map that can be used to take into account the higher order aberrations within an optical proximity correction simulation kernel. The method may use either simulated wavefront

information or empirically derived information. *The wavefront information is modeled within an array, whose elements are reordered, given a complex conjugate correlation, operated upon by a filtering function, and subjected to a fast Fourier transform and later an inverse Fourier transform.* Specification, ¶ 0103 (emphasis added).

Applicants submit that the claim amendments to claims 31-33 clarify the output of the methodology for these embodiments as a data file containing a transformed array of a phase map.

### **Rejections under 35 U.S.C. § 101**

The Examiner has rejected claims 1-30 under 35 U.S.C. § 101 because the claimed invention is directed to non-statutory subject matter. Specifically, the Examiner asserts that the current state of the claim language is such that a reasonable interpretation of the claims would not result in any useful, concrete, or tangible product. The Examiner states that generating a corrected phase map, or outputting of a corrected VLSI layout mask, remains in the abstract. Applicants respectfully disagree.

The present invention computes "a phase map that can be used to take into account the higher order aberrations within an optical proximity correction simulation kernel, which results in a more accurate computation of OPC when long-range effects become prominent." Specification, ¶ 0046. As previously discussed, the phase map is a transformed array – a data file.

The step of normalizing *the transformed array's* amplitudes comprises: subtracting an average value of the wavefront from each array element; and replacing each of the elements by an analytical expression, which is a function of both a square root of intrinsic flare and a radius of the wavefront. Specification, ¶ 0027.

The wavefront is then computed by applying a Fourier transformation to *filtered array A*. A shuffling mechanism *may be applied to the array* to enable

the array to be used in a commercially available Fast Fourier Transformation tool. Specification, ¶ 0074.

In a decision dealing with computer-related inventions, the Supreme Court affirmed the potential patentability of an industrial process which included as one of its steps the use of a mathematical formula and a programmed digital computer to do calculations. Diamond v. Diehr, 450 U.S. 175, 209 USPQ 1 (1981). In Diamond v. Diehr, the Supreme Court held that a process for curing synthetic rubber, which includes the use of a mathematical formula and a programmed digital computer, constituted patentable subject matter under 35 U.S.C. § 101. The Supreme Court affirmed that "an application of a law of nature or mathematical formula to a known structure or process may be well deserving of patent protection." Id. at 187, 209 USPQ at 8.

The Court further stated: "When a claim containing a mathematical formula implements or applies that formula in a structure of process, which, when considered as a whole, is performing a function which the patent laws were designed to protect (e.g., transforming or reducing an article to a different state or thing), then the claim satisfies the requirements of § 101." 209 USPQ at 10.

Applicants respectfully submit that the claims of the instant invention meet the Supreme Court test for patentability. The scientific principles recited in the claims are not being claimed in the abstract. Applicants are not attempting to patent a mathematical formula. A phase map is being created, which is used in the fabrication of semiconductor wafers. This phase map is a transformed data array that persons having ordinary skill in the art use in the semiconductor wafer fabrication process. In this manner, the manipulation of

data as part of the process to create a phase map, in the form of a transformed array, has a claimed practical application.

Applicants further submit that the claimed subject matter is patentable as supported by the CCPA's two-part test:

First, the claim is analyzed to determine whether a mathematical algorithm is directly or indirectly recited. Next, if a mathematical algorithm is found, the claim as a whole is further analyzed to determine whether the algorithm is 'applied in any manner to physical elements or process steps,' and, if it is it 'passes muster under § 101.' In re Abele, 684 F.2d 902, 915, 214 USPQ 682, 675-76 (CCPA 1982).

Applicants respectfully submit that the claims of the instant invention represent statutory patentable subject matter under 35 U.S.C. § 101. The process steps generate a transformed array or phase map that is a necessary element of semiconductor wafer processing.

### **Rejections under 35 U.S.C. § 103**

Claims 1-3, 20-21, and 27-29 stand rejected under 35 U.S.C. § 103(a) as being obvious from Baggenstoss, et al. (U.S. Patent No. 6,374,396), in view of Neureuther, et al. (U.S. Patent No. 7,030,997), and in view of Fukuda ("Determination of High-Order Lens Aberration Using Phase/Amplitude Linear Algebra," 1999). Applicants respectfully traverse this rejection.

The Examiner agrees with the applicants' previous argument, inasmuch as Baggenstoss does not explicitly disclose performing OPC calculations that account for higher order aberrations. However, the Examiner attempts to combine Fukuda to teach a point spread function that can be used to measure higher order aberrations. Applicants disagree with this combination.

First, in accounting for higher order aberrations, one cannot rely on OPC tools that do not consider the higher order effects, or on methodologies that utilize the Zernike polynomial, as does Baggenstoss, Neureuther, and Fukuda. Baggenstoss relies on calculations using the Zernike polynomial, which means that Baggenstoss does not accommodate higher order effects; rather, Baggenstoss emphasizes the lower order aberrations. Effectively, Baggenstoss teaches away from any accounting of higher order aberrations. Neureuther teaches using the Zernike polynomial as well, which by its nature excludes higher order aberration effects. The Examiner's combination of Fukuda does not remedy the absence of higher order calculations.

The present invention takes into account flare, which is the image component generated by high frequency phase "ripples" in the wavefront. Flare arises when light is forward scattered by appreciable angles due to phase irregularities in the lens. Such irregularities are often neglected for three reasons. First, the wavefront data is sometimes taken with a low-resolution interferometer, and may be reconstructed using an algorithm of even lower resolution. Second, even when the power spectrum of the wavefront is known or inferred, the high frequency wavefront components on the image cannot be included since the image integral is truncated at a very short ROI distance, causing most of the scattered light to be neglected. Last, it is not a general straightforward process to include these higher order terms in the calculated image, and the higher order terms are predominantly ignored.

The present invention requires the optical kernel to accommodate a spatial frequency that is in the micron range, on the order of  $2\mu$  or less. Moreover, the present invention includes flare. Both conditions require the accommodation of higher order aberrations on the

order of  $10^{10}$ . ("First, wavefront roughness or high order wavefront aberrations, which encompass up to approximately  $10^{10}$  Zernikes, cause flare." Specification, ¶ 0008).

Fukuda is a low order Zernike calculation. To be precise, Fukuda teaches no more than 37 Zernike terms (third order), which cannot possibly attain a spatial frequency of  $2\mu$  or less. The present invention accommodates approximately  $10^{10}$  Zernike terms in order to consider the effects of flare and a spatial frequency of  $2\mu$  or less. Applicants respectfully submit that the prior art cited by the Examiner cannot be used to perform the method taught and disclosed by the present invention. The prior art cannot accommodate a small spatial frequency, nor can the prior art, separately or in combination, consider  $10^{10}$  Zernike terms. The cited prior art cannot perform the higher order calculations.

Applicants have amended the claims to specifically state that the method accommodates flare and a spatial frequency of  $2\mu$  or less, which sets a higher order term boundary condition that the prior art cannot possibly meet.

The Examiner has rejected claim 26 under 35 U.S.C. § 103(a) as being unpatentable over Wong, et al. (U.S. Patent No. 6,223,139) in view of Fukuda. For the reasons cited above, applicants traverse this rejection.

Wong requires determining a sample range and spatial sampling intervals, which are dependent upon the wavelength, numerical aperture, and partial coherence of the exposure system. Wong chooses to eliminate higher order aberrations due to the complexity and inefficiency of the computations. "Since the imaging system is band-limited, i.e., it passes low spatial frequencies but cuts off high frequencies, the sampling interval is given by:  $d\lambda/(NA(1+\sigma))$ , where  $d=0.5$ ." Wong, col. 7, l.65 – col. 8, l.6.

For partially coherent systems, optical interaction among patterns on the photomask has a finite range. In aerial image computation, the use of a sampling range smaller than the interaction range results in inaccurate calculation. *On the other hand, the use of an unnecessarily large sampling range increases the size of the characteristic matrix and, hence, reduces computation efficiency.*

Wong, col. 8, ll.12-18 (emphasis added).

Moreover, Wong's method is characterized in that the characteristic matrix is precisely defined by the sampling range and the sampling interval, such that the sampling range is the shortest possible and the sampling interval, the largest possible, without sacrificing accuracy. Wong, abstract.

Wong purposely teaches away from using calculations that would account for higher order aberrations by eliminating large sample ranges from consideration. At best, combining Wong with Fukuda would only allow for 37 Zernike terms. This would certainly not accommodate any calculation of flare or a spatial frequency of  $2\mu$  or less.

The Examiner has rejected claims 31-33 under 35 U.S.C. § 103(a) as being unpatentable over Neureuther in view of Fukuda. Again, for the reasons cited above, applicants traverse this rejection.

These prior art references cannot accommodate flare or a spatial frequency of  $2\mu$  or less. Much higher order Zernike terms are required than a third order (37) and that is the extent of the combination of Neureuther and Fukuda.

Applicants submit that the claims, as amended, are patentably distinct over the cited prior art.

#### **Allowable Subject Matter**

The Examiner has objected to claims 4-19, 22-25, and 30 as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of

the limitations of the base claim and any intervening claims, as well as overcoming the 35 U.S.C. § 101 rejections further identified. Applicants respectfully submit that the amendments to claims 1 and 27 place the above-objected claims in a condition for allowance.

It is respectfully submitted that the entire application has now been brought into a condition where allowance of the entire case is proper. Reconsideration and issuance of a notice of allowance are respectfully solicited.

Respectfully submitted,

A handwritten signature in dark ink, appearing to read 'R. Curcio', is written over a horizontal line.

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